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## Understanding Biology Teachers' Pedagogical Content Knowledge for Teaching "The Nature of Organism"

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**Abstract**

Effective and experienced teachers have the capacity to transform and enact subject matter into forms that can be understood by students. The capacity to transform depends on the blending of content and pedagogy and it is conceptualised as pedagogical content knowledge (PCK). The purpose of this study is to investigate the understandings and practices that comprise a biology teacher's PCK. In this research, the research participant demonstrated her PCK through writing a content representation (CoRe), teaching in the classroom, and discussion during the interview. The researcher determined the extent and nature of her PCK in relation to the Magnusson et al (1999). The findings expose the teacher's understanding and practice of PCK supported teaching and learning science based on constructivism. The teacher had strong, clearly articulated views on the NOS which she implemented all components of PCK confidently into her teaching.

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**Keywords:** Pedagogical Content Knowledge (PCK), Content Representations (Cores), Biology Teachers, Experience Teachers;

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**1. Introduction**

The Thai National Education Act B.E. 2542 seeks to improve the quality and relevance of education throughout the Thai education system (ONEC, 1999). The Act focuses on a teaching and learning reform through an implementation of a student-centered approach as a new method of teaching and learning. The success of educational reform depends on the quality of

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teachers and their cooperation (Jurawatanaton, 2003). The role of the teacher as facilitator and the learner-centered approach, based on constructivist-based teaching and learning perspectives, will contribute to the success of learning reform in Thailand (OEC, 2004). The National Science Education Reform advocates that science teachers should engage students in doing and thinking about inquiry, and renew emphasis on teaching about the nature of science (Institute for Promotion of Teaching Science and Technology [IPST], 2002b). Some science teachers attempt to acquire knowledge for teaching, that is pedagogical content knowledge [PCK], because this knowledge helps them to create constructivist classrooms and provides the opportunity for their students to learn science through an inquiry approach. PCK has been described as the hallmark of teaching and PCK has become a central focus in learning how to teach particular subjects. It shows that teacher is the expert teacher and the professional teacher.

### **Exploring PCK to learn about teaching**

Pedagogical content knowledge (PCK) was originally introduced by Shulman (1987) to enclose a category of teachers' professional knowledge determined to each individual teacher. Shulman (1987) originally defined PCK as “the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learning, and presented for instruction” (p.8) and “the particular form of content knowledge that embodies the aspects most germane to its teachability” (p.9).

PCK also is “...knowledge of the transformation of several types of knowledge for teaching (including subject matter knowledge), and that as such it represents a unique domain of teacher knowledge” (Magnusson, Krajcik and Borko, 1999: 95). In addition, PCK is a unique knowledge processed only by individuals within the profession of teaching, and consequently the concept of PCK is useful to help teachers' understandings what teachers know, what teachers ought to know, and how they might develop it (Baxter and Lederman, 1999; Park, 2005).

Geddis (1993) argued that science teachers with well developed PCK are effective teachers because they realize the importance of students of understanding science concepts and were able to utilise a range of effective and appropriate teaching methods and instruction strategies to develop students' science concepts.

Magnusson et al. (1999) conceptualized pedagogical content knowledge for science teaching as consisting of five components :

- orientations towards science teaching (since teacher's knowledge and beliefs related to their teaching goals and approaches will influence their classroom practice)
- knowledge of curriculum
- knowledge of assessment (since what is to be assessed, how and why, also influences a teacher's practice)
- knowledge of students' understanding of science
- knowledge of instructional strategies

Loughran et al. (2006) try to construct explicit correlation that is available between the knowledge of content, teaching and learning for science teacher. Content Representation (CoRe) as originally devised, represent conceptualizations of the collective PCK of expert teachers

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around a specific science topic, including “the key content ideas, known alternative conceptions, insightful ways of testing for understanding, known areas of confusion, and ways of framing ideas to support student learning” (Loughran et al. 2008, p.1305). In essence CoRes try to portray holistic overviews of teachers’ PCK related to the teaching of a specific science topic. Presented in the format of Resource Folios, the CoRes are accompanied by Pa-PeRs, which illustrate how specific aspects of the topic aligned to the CoRe are brought to life in teaching by expert teachers. PaP-Rs are narrative accounts designed to illustrate specific instances of that PCK in action.

## **2. Purpose of the study**

This study examines the nature of a biology teacher’s pedagogical content knowledge (PCK). The research objectives is expressed through the research question:

- What are the understandings and practices that comprise a biology teacher’s PCK?
- To what extent did the content of CoRe reflect the components of PCK as identified by Magnusson et al. (1999)?

## **3. Methodology/Experimental design**

This study constitutes a report of case-study method used to look at how mentor science teachers conceptualised their own PCK that impacted their teaching practice. According to Merriam (1998), this research method is the best vehicle for providing ‘intensive descriptions and analyses of a single unit or bounded system such as an individual, program, or group’ (p. 19). By employing case-study methods, our intent was to represent the teachers’ understanding of the situation and share their meaning with all involved in the research.

### **Participant**

The participant in this study was a biology teacher who was teaching at the secondary school level (grade 10) in public school under Secondary Educational Service Area Office 20. To protect her privacy she was given pseudonyms, Ms. Pat.

Ms. Pat, who was 45 years old, has Master’s degree of Science Education. She has been teaching biology for 15 years. There were 52 students per classrooms and she taught 4 classrooms and she taught for 12 hours per week. Her expectations for teaching biology is that when students get the knowledge and skills from learning biology, they can take the knowledge and skills to use in their life and they have knowledge that can be the basis for further study at higher levels.

### **Data Collection**

The researcher introduced CoRe template to Pat, we talked and discussed about the CoRe template. More specifically, the researcher took the example of CoRe that is a representation of PCK for the topic Circulatory System (John Loughran et al. 2006) to Pat. We discussed about the topic that Pat need to write in CoRe. The topic she chose was on “The nature of organism”. After one week, the research observed and video recorded teaching in her classroom. When she finished teaching, the researcher interviewed 52 students in classroom. The

researcher used the interview form that the students need to write. After that, the research interviewed Pat by using a semi-structured interview and voice recorded the interview. In this research, classroom observation, and interview were used as research methods to provide opportunities for participant and the researcher to generate an understanding for a particular situation. The researcher used the extent and nature of PCK in relation to the Magnusson et al. (1999) model as illustrated in the CoRe content and her comments in interviews.

### **3. Results and Discussion**

#### **Orientation to Teaching Science**

Pat's understanding about articulating goals and purposes for teaching science was rich and consistent with educational reform and science education as highlighted for Scientific Literacy. As she wrote, in expectations for teaching biology form: "The students should understand science content in biology. They can conduct experiments by science process skills, and apply science knowledge into their daily lives. The students can explain how to get science knowledge or understand the nature of science. As shown below:

Researcher : Could you describe me more about the nature of science?

Pat : Science knowledge is fact, theory, or law that can explain natural phenomena and science process skills are used for gathering the knowledge. The science knowledge can be changed if there was new evidence.

Researcher : What else do you think your students should learn from your class?

Pat : Students can present and discuss what they learn through inquiry activities with other students. They can use this knowledge to make decision for their daily lives such as buying food, solving pollution in their community or maintain their high quality of lives in society. (Pat's Interview)

#### **Knowledge of students' understanding of science**

Pat's understanding about student's understanding of science is captured through the scientific process. Students learning science concepts is acquired through experimentation and the practice of scientific skills in constructing scientific knowledge. Pat understanding as showed in CoRe;

"students surveyed the features of organisms found in the nature. For example, students surveyed the asexual reproduction organism found around school and they took the example of asexual reproduction organism to discuss in their group and present in classroom."

With regard to Pat's teaching , she used instructional media inside and outside classroom. She used them to provide a variety of learning activities that motivated students' learning. She used Microsoft office powerpoint programme to present the frog's reproduction, the budding of hydra and yeast, binary fission of Euglena and amoeba reproduction. She realized the different needs of students and the ability of the students. She understood that is students' is learning through sharing, working and discussing with other students. The following evidence as shown in the interview;

Pat : I think working as group is the best way for students to learn how to interact with each other. I usually teach students in groups because they can help each other.

Researcher: That is a good point. What do you think about the influence of interaction on student's learning?

Pat: I think when students learn together, they have interaction with their friends. I think if I can organize students' learning through group work. They were conceptualized to learn about social interaction. They should be good citizens for the community, society, and the nation.

Researcher: How many students per group?

Pat: There are about 4-5 persons per group and the group has mixed ability and gender students, students would get intellectual influence. They can share any knowledge that they have at different levels. (Pat's Interview)

### **Knowledge of instructional strategies**

Pat understood about instructional strategies that are consistent with educational reform. She focused on the different needs of students and she realized that a student's prior knowledge was very important to her teaching. In her teaching, it was shown that Pat had understanding of students' prior knowledge. She stimulated students' curiosity using questioning, discussing, and interacting with real things. The teacher used a picture of the growth of starfish and the regeneration of tail house gecko. The teacher and the students together discussed about picture. As the following;

Teacher: What are the similarities and differences in picture A and picture B?

Student 1: It is the same, it can regenerate.

Teacher: What is the difference between picture A and picture B?

Student 2: In picture B, there is no increase in the number of body.

Teacher: What is the opinion of other students?

Student 3: When the house gecko has generated, it is still one but when the star fish has generated, it has two body.

Teacher: The starfish separate in two pieces but the house gecko has generated tail, it is still the one. Which the regeneration of two animals is the reproduction?

Every students said: The star fish.

Teacher: why do you tell me is that the star fish?

Student 4: Because the star fish separates in two pieces and they are generation to 2 star fish, so it can increase the number.

Teacher: Does it look like the original star fish?

Student 1: Yes, it is the same.

Teacher: So, the picture A is the reproduction because they have the progeny with the same parent and increase the number. The picture B is not the reproduction but it is repairing the body. (Pat's classroom observation)

The findings of Pat's teaching demonstrated her understanding of teacher's role for inquiry-based teaching and learning based on constructivism. In CoRe, she designed the investigation to encourage students to survey about asexual reproduction pattern that is found in nature around the school. The students can observe that the animal and plant exist in variety in the nature. She told to the students "you have 15 minutes to survey and for you to collect the sample of asexual reproduction organisms. Which the sample that you choose shows the asexual

reproduction pattern? And you have to discuss in your group, and you are to present the data in the classroom.”

### **Knowledge of science curriculum**

Pat's understanding about science curriculum that her school has developed the curriculum which was refereed from the standard curricular that was created by the Institute of Promotion of Science and Technology Teaching (IPST). Pat is the head of department in her school. She was one of the member of school-based science curriculum developers. She had experience of developing the school-base science curriculum . As she mentioned during the individual interview,

“...The way I developed school-based science curriculum was based on the national science curriculum and combined with school and community contexts. I use school-based science curriculum as my reference for teaching and learning science because it was related to teaching and learning goals for the school. I think that the goals and purpose for teaching and purpose for teaching and learning science” Mostly, in her CoRe, she provided the topic concept about the nature of organism was what is Biology? What is the organism ? and biology with activity in daily lives. These topics are relevant to the school-based science curriculum.

### **Knowledge of assessment of science**

The results from CoRe, interview and classroom observations showed that Pat's understandings about assessment of science. Her understanding of formative assessment, shown through her comments in that assessment of student learning is an ongoing process occurring throughout learning and teaching activities. As she said “Students were assessed at the beginning or the end of the teaching class and the assessment methods should be variety for assessing student learning in the classroom. Students should be evaluated and assessed through many ways and by many persons, not only teacher. Especially, authentic assessment should be integrated into class.”

With regard to Pat practices as shown in CoRe, she used various types of assessments methods such as multiple choice tests, observation during student activities, member checking, written journal, drawing, practical homework or concept mapping to evaluate students' understanding science.

During the classroom observation, Pat planned for the students to survey the asexual reproduction of plant and animal around the school and discussed in their group and work cooperatively. To assess student learning outcomes, Pat used multiple choice tests but she also asked students about reason. In addition, she also used observation during student activities, she asked questions to assess the students to know about their learning in the topics that was taught. She developed worksheets related to asexual reproduction and sexual reproduction ; provided a chance for students to assess their group members in aspect of sharing and working in a group, and assigned students to do practical homework.



#### 4. Conclusion

The findings of the understanding of the component about biology teacher who has PCK to teach the topic “The nature of organism” showed the teacher has own PCK. The teacher’s awareness of the nature of the components that serve as the foundation for PCK (Magnusson et al., 1999) ; The results of the case study teacher indicated that she had good understanding and practices of PCK that supported her to be more confident in integrating the various aspects of PCK ie. orientation to teaching science, knowledge of science curricular, knowledge of students’ understanding of science, knowledge of instructional strategies, knowledge of assessment of scientific literacy in her classroom practices.

#### 5. Implications for teaching science through integrating PCK.

The results of study suggest several aspects need to be addressed for science teachers to be successful in integrating PCK in their teaching of science. First, the science teacher needs to hold the goals and purposes that focus on student learning with respect to science knowledge, science process skills and scientific attitude. Second, strong subject matter knowledge would make it easier for the science teacher to teach science through inquiry-based teaching and learning and the students should be taught science by inquiry approach. Third, the science teachers have to construct a good relationship with students. Finally, science teaching and learning should refer to school and community context as learning resources.

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